TA No.2193-IND

ASIAN DEVELOPMENT BANK

ENERGY EFFICIENCY SUPPORT PROJECT

SECTOR ANALYSIS
SUGAR INDUSTRY

SUPPORTED BY
GOVERNMENTS OF THE NETHERLANDS AND INDIA

EXECUTING AGENCY
THE INDUSTRIAL CREDIT AND INVESTMENT CORPORATION OF INDIA LIMITED

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April 1996

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Executive Summary

The Government of Netherlands (through the Asian Development Bank) and the Government of India has jointly launched a project entitled 'Energy Efficiency Support Project' (ESP) to look into various aspects of energy and environment issues pertaining to the Indian industry. The project comprises of two distinct phases. Phase-I of the project deals with identification of industry sectors where there is a substantial scope for energy saving and pollution reduction through energy efficiency investments. Phase-II of the project primarily covers various initiatives like undertaking energy and environment audits, feasibility studies, training programmes and promotional campaigns for the industry sectors identified under the phase-I of the study. One of the sectors to be covered for detailed analysis by TERI under phase-I is the sugar sector, a macro assessment of which is presented in this report.

India is the world's largest producer of sugar and the industry is expected to grow at a rate of around 5% p.a. The Indian sugar industry is unique in more than one way - cooperative sector accounts for more than 58 % of the installed capacity, atleast half of the existing sugar factories are more than 25 years old and the average crushing capacity is only 2035 TCD compared to plants of 8000 TCD and more in developed countries. Inspite of being the world's largest producer of sugar, the per capita consumption of sugar in India is only 14.6 kg compared to 30 - 50 kg in the developed countries. The sugar production is highly dependent on the availability of cane. Apart from the weather playing a crucial role in the availability of cane, the other competing uses of cane are the production of gur and khandsari - the traditional forms of sugar, manufactured in the cottage industries. The sugar industry appears to be poised for a major expansion, especially considering the record production of 14.5 million tonnes in 1994-95. On the other hand, certain sections of the industry strongly feel that the industry can face unprecedented financial crisis in the future if certain concrete steps are not taken by the Government to decontrol the industry. The sugar industry is still one of the most regulated industries in India. The controls exist right from the stage of setting up of new capacities to the sale of sugar by way of levy/non-levy quota and the regulated release of monthly quotas of sugar by the Govt to keep the sugar prices under check. The rather cyclical nature of sugar production witnessed in the past in a way explains the impacts of this controlled regime. The fall in the price of sugar in a year, which is normally due to production exceeding the demand, discourages the cane growers, who switch to other crops

in the following years. This creates a deficit in production, thus resulting in a surge in market prices.

The average steam consumption of the Indian sugar mills is around 0.55 tonnes of steam per tonne of cane crushed while the average electricity consumption is around 24 Kwh per tonne of cane crushed. The Government of India has specified a steam consumption norm of 0.50 tonnes per tonne of cane crushed as a maximum limit for new factories (set up on 1987 standard specifications). The total absolute primary energy consumption in the industry is around 100 million Gcals. The energy consumption in the Indian sugar industry is high mainly because of (i) the presence of a large number of small sized inefficient mills (ii) non-incorporation of energy saving devices and inadequate implementation of energy conservation measures. The scenario can be improved in the mills by optimising the process steam requirements, upgradation of steam generating parameters for adopting advanced cogeneration systems and by employing energy efficient technologies in various sections of the plant. Adoption of these measures can help in reducing the energy consumption in plants by around 20%.

Setting up of high pressure cogeneration plants has been identified as one of the major energy saving measures for the sugar mills. Preliminary studies carried out by various agencies have put the total cogen potential to be atleast 3500 MW. Venturing into the field of commercial cogeneration offers numerous advantages to the sugar mill owners, the major one being the possibility of additional revenue inflows by way of sale of excess electricity. This additional business opportunity can help the mills in improving their financial health. Bagasse based cogenerators feeding to the grid can also help in partly meeting the growing power demand in the country. The other major energy saving opportunities in the sugar mills are:

- steam economy in evaporator section (e.g. falling film evaporators)
- use of continuous vacuum pans
- use of hydraulic drives
- bagasse drying
- use of continuous centrifuges
- energy saving measures in boiler section (e.g. economisers, air preheaters etc.)

There are basically two sources of pollutants from sugar plants - one caused by flue gases from the boilers and the other caused by the wastewater from the various sections of the plant. Generically, the extent of pollution can be considered to be high from the sugar mills. Atleast 30% of the plants are not having adequate facilities to comply with emission standards.

Considering the immense scope for energy conservation in the sector and the social and national benefits to the country at large, it is recommended that the sugar sector be considered for assistance under the second phase of ESP. There are good opportunities for replication in the sector since there are already 450 mills and several new sugar mills are expected to come up in the near future. Based on the comparative assessment, the sector has been choosen for the second phase of the Energy Efficiency Support Project.

CHAPTER 1

Introduction

The Government of Netherlands (through the Asian Development Bank) and the Government of India has jointly launched a project entitled 'Energy Efficiency Support Project' (ESP) to look into various aspects of energy and environment issues pertaining to the Indian industry. The project comprises of two distinct phases. Phase -I of the project deals with identification of industry sectors where there is a substantial scope for energy saving and pollution reduction through energy efficiency investments. Phase-II of the project primarily covers various initiatives like undertaking energy and environment audits, feasibility studies, training programmes and promotional campaigns for the industry sectors identified under the phase - I of the study.

The specific objectives of the study are outlined below.

(i) To identify industry sectors which offer high potential for energy savings and environmental benefits.
(ii) Identify industry sectors which have high potential for investment opportunities for energy efficiency and environmental improvements.
(iii) To enunciate energy conservation measures that can be implemented bringing out likely benefits of the major energy conservation measures at a macro level and
(iv) Identify potential industrial units under each of the sectors where the energy and environmental audits can be carried out on a cost sharing basis.

Under the Phase I of the study, one of the sectors to be covered for detailed analysis by TERI is the sugar sector. This sector was selected because of the enormous scope of energy conservation in the sugar factories.

CHAPTER 2

Sector Profile

2.1 Overview of the sugar industry

India is the largest producer of sugar in the world. The inception of the sugar industry in India can be traced to the beginning of the current century, when a few sugar mills were set up in the states of Uttar Pradesh and Bihar. As a historical perspective, in 1931-32, there were 31 factories which gradually increased to about 150 at the time of independence in 1947. Sugarcane is the major raw material for sugar production and the availability of cane for the sugar mills in a particular year determines the level of sugar production in the country. Cane is grown in several states, the major ones being Uttar Pradesh, Bihar, Punjab, Haryana, Andhra Pradesh, Tamil Nadu, Karnataka, Gujarat and Maharashtra. These nine states account for nearly 95% of the total sugarcane production in the country. Sugarcane is a seasonal crop. Accordingly, the sugar season starts in October and continues upto March/April. As per The Directorate of Economics and Statistics, Ministry of Agriculture, the estimated area under sugarcane cultivation in 1993-94 was 33,85,800 hectares resulting in a total sugarcane production of around 2330 million tonnes. The per hectare yield varies widely from one state to another. It is lower in sub-tropical regions as compared to the tropical belt. In the tropical region, Tamil Nadu has the highest yield of 105.4 tonnes/hectare against the all India average of 67.1 tonnes/hectare. Annexure I shows the area under sugarcane cultivation, sugarcane production and the yield in different states for the year 1993-94. The sugarcane recovery (expressed as percentage recovery) also varies from one state to another, mainly due to the varying quality of cane. It varied from 7.9% to 11.3% with an All India average figure of 10.3% in the 1992-93 season. The utilisation of cane for sugar production increased from about 35.5% in 1984-85 to around 53% in 1991-92 season which again declined to 43.3 % in 1993-94. This was mainly due to severe diversion of cane for alternative uses i.e. gur and Khandsari[1] (Annexure II). With rising population and levels of income increasing gradually, the demand for sugar is increasing and it is expected that greater share of cane will be used for sugar production in future.

Under the present sugar cane policy, a Statutory Minimum cane price payable by the factories is fixed by the Central Government every year. These prices serve as floor

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[1] Gur and khandsari and traditional forms of sugar produced through an open pan process at atmospheric pressure, through traditional methods. The extraction process is highly inefficient and a portion of the sugar in the cane remains unrecovered.

prices. However, each State Government announces the State Advisory price to be paid by the Sugar factories. The minimum statutory price of cane has increased steadily for Rs 7.37 per quintal in 1967-68 to Rs. 39.10 per quintal in 1994-95.

2.2 Production

In the post independence period, the developments in the sugar production have been phenomenal. Presently, there are nearly 450 sugar mills and the sugar production reached an all time record level of 14.5 million tonnes this year (1994-95) surpassing the previous high of 13.4 million tonnes achieved in 1991-92. The statewise sugar production from 1982-83 till 1993-94 is given in Annexure III. The fall in production in 1992-93 and 1993-94 (10.6 and 9.8 million tonnes respectively) is attributed to the higher diversion of cane to gur and khandsari and fall in the cane/sugar production in the state of Maharashtra.

India had been importing sizeable quantities of sugar to meet its requirements until 1957. Since 1957, the imports have gradually reduced and India has been exporting small quantities of sugar (0.1 to 0.9 MTPA) consistently, after meeting its domestic demand. However, India's share in world exports in this commodity (sugar, sugar preparations and honey) is negligible and has almost always remained less than 1%. Occasionally, it has to still resort to imports when the cane production goes down due unfavourable weather conditions. As an example, in the last season (1993-94), the country had to resort to imports to meet the domestic demand. Annexure IV gives the data on the number of factories in operation, production, imports, exports and internal consumption of sugar from 1960-61 to 1993-94.

2.3 Licensing of Capacity in Sugar Industry

Licensing of capacity of sugar industry is regulated by the Government of India. The guidelines presently being pursued for the purpose were issued in 1991-92. The main features of the existing sugar policy are given below :

1) New Sugar factories will continue to be licensed for a minimum economic capacity of 2500 tonnes cane crushed per day (TCD). There will not be any maximum limit on such capacity. However, in areas specified as industrially backward areas by the Government of India and certified by the Indian Council of Agricultural Research to be agro-climatically suited for development of sugarcane, licensing of new sugar factories in the co-operative and public sectors would be allowed for an initial capacity of 1750 TCD subject to the condition that the units would expand their capacity to 2500 TCD within a period of 5 years of going into production.

2) Licenses for new sugar factories will be issued subject to the condition that the distance between the proposed new sugar factory and an existing/already licensed sugar factory should be 25 kilometers. This distance criterion of 25 kms could however, be relaxed to 15 kilometers in special cases where cane availability so justifies.
3) The basic criterion for grant of licenses for new sugar units would be their viability, mainly from the point of view of cane availability and potential for development of sugarcane.
4) All new licenses will be issued with the stipulation that cane price will be payable on the basis of sucrose content of sugarcane.
5) Other things being equal, preference in licensing will be given to proposals from the Co-operative sector and the Public sector, in that order, as compared to the private sector.
6) Priority will be given to sugar factories with capacity less than 2500 TCD to expand to the aforesaid minimum economic capacity.
7) While granting licenses for new units and expansion projects, the additional capacity to be created upto to the end of the Eight Plan, i.e. 1996-97, will be kept in view.
8) While granting licenses for new sugar factories, industrial licenses in respect of down-stream units for the use of molasses i.e., industrial alcohol etc. will be given readily.

The licensed capacity at the end of 1993-94 stood at about 202 Lakh tonnes and the installed capacity was about 115 lakh tonnes. The actual figures of licensed capacity and installed capacity at the end of years 1990-91, 1991-92, 1992-93 and 1993-94 are given in Table 1:

Table 1. Licensed and installed capacity of Sugar Industry.

Lakh Tonnes

Year End	Licensed Capacity	Installed Capacity
1990-91	170.41	98.48
1991-92	175.57	102.40
1992-93	176.72	109.41
1993-94	202.42	115.45

Source. Indian Sugar Year Book, Volume I, 1993-94.

As can be seen, the licensed capacity is far in excess of the actual installed capacity in the industry. The corresponding total number of licensed sugar factories and actual number of installed sugar factories as on 30th September, 1994 were 572 and 429 respectively.

2.4 Demand estimates

Annexure IV shows the comparative supply and demand situation of sugar in the country for the past three decades. As can be seen, the sugar production has been inconsistent and depends to a large extent on the cane production/availability to the sugar units. Inspite of being the largest sugar producer in the world, the per capita sugar consumption in India is only around 14.6 kgs against 30-50 kgs for developed world. The per capita consumption is expected to grow gradually in the future and is projected to be around 16.75 kg by the turn of the century. The Planning Commission has worked out the projections for targeted production upto the year 2000 based upon the past trends (growth rate in the last five years was 5.7% p.a.) and expected growth rate of around 5%. The estimates of sugar consumption and targeted production levels (using the base year 1988-89) are given in Table 2. To meet these production levels, the installed capacity of sugar industry is also expected to go up sharply in the near future. A large number of new sugar mills are coming up in different parts of the country and many of the existing mills are expanding their capacities to meet the growing demand. In addition to the 572 licensed sugar mills as on 30th September, 1994, latest figures state that more than 300 applications for new licenses/ expansion are pending before the Sugar Licensing Committee, under the Ministry of Food, Government of India.

2.5 Sugar mills distribution pattern

Sugar mills in India are either privately owned, publicly owned or owned by co-operatives. Of the 429 installed sugar mills in the country (as on 30 September, 1994), 240 are in co-operative sector, 117 in the private sector and only 72 are in the public sector. The cooperative sector accounts for more than 58% of the installed capacity in the country. The states which lead in this movement for establishment of cooperatives are Maharashtra followed by Uttar Pradesh whereas states like Bihar have sugar industries mainly in private sector. Sugar cooperatives, owned largely by small planters, are organized in state federations, which, in turn, are coordinated by the National Federation of Cooperative Sugar Factories (NFCSF); NFCSF represents the interests of its members at the national level and to a certain extent in the provision of technical assistance to sugar cooperatives. Sugar mills in the private and joint sectors are grouped in the Indian Sugar Mills Association (ISMA), which aims at furthering the interest of its members at the Government level.

The capacity range of sugar factories in our country varies from 400 TCD to 7000 TCD. The percentage break-up of the sugar factories according to capacity range is given in Table 3.

Table 2. Demand projections

Year	Internal consumption (million tonnes)	Production target (million tonnes)
1995-96	13.93	14.08[2]
1996-97	14.63	14.79
1997-98	15.36	15.53
1998-99	16.13	16.30
1999-2000	16.94	17.12

Source.DST, 1990

Table 3. Capacity range of sugar factories

Size range	%
Below 1250 TCD	16
1250 TCD	31
1251 TCD to 2000 TCD	17
2001 TCD to 2500 TCD	22
2501 TCD to 3500 TCD	7
Above 3500 TCD	7

The situation for the new mills which are coming up in the country is somewhat different. The minimum economic size of the plant which can be set up today is of 2500 TCD and the Government of India is encouraging the entrepreneurs to expand their plant capacities to 5000 TCD and beyond. As a result, more and more plants with capacities much higher than 2500 TCD are now entering in the Indian sugar industry. However, even now, the average cane crushing capacity in India is far lower (2035 TCD in 1993-94) as compared to international standards . The average size of sugar plants in Australia is 8268 TCD, in Brazil it is 8296 TCD while in Cuba it is 4037 TCD. To illustrate this further, Australia has only 28 sugar factories which produce 4.5 million tonnes while there are nearly 400 operating mills in India producing around 12 million tonnes of sugar.

The uneconomic size of plant and obsolescence of plant and machinery are major problems of the Indian sugar industry. The technologies adopted in many of the sugar factories are outdated, because these plants were set up long back. This can be seen from Table 4 which shows the percentage share of plants having different vintage.

Table 4. Grouping of plants as per vintage

[2] Recent reports point out that the sugar output in 1995-96 is estimated at 15 million tonnes, since the area under sugarcane cultivation has risen by 12%. This is especially so due to the high production level of 14.5 million tonnes achieved in the last season as against the figure of 11.8 million tonnes estimated earlier (which has lead to the complications in cancellation of the import orders by the Government of India).

Age	%
Up to 5 years	5
Between 6 to 15 years	22
Between 16 to 25 years	21
Between 26 to 35 years	13
More that 35 years	39

As can be seen from this table, more than half of the sugar factories are more than 25 years old, resulting in high down time,low capacity utilisation and other associated problems. Hence, the sector has both plants which have good financial health (a few private sector units) and a fairly large number of old inefficient cooperative sector units with poor financial capabilities to invest in energy conservation/environmental improvement measures.

2.6 Manufacturing process technology

The sugar manufacturing process normally comprises of juice extraction, juice clarification, evaporation, crystallization, centrifuging, drying, and packing. Steam generation using bagasse as the fuel and electricity generation, mostly through back pressure turbines forms an important part of any sugar factory. Typical flowsheet of a sugar mill is shown in Figure 1. A brief description of the various process steps is provided below:

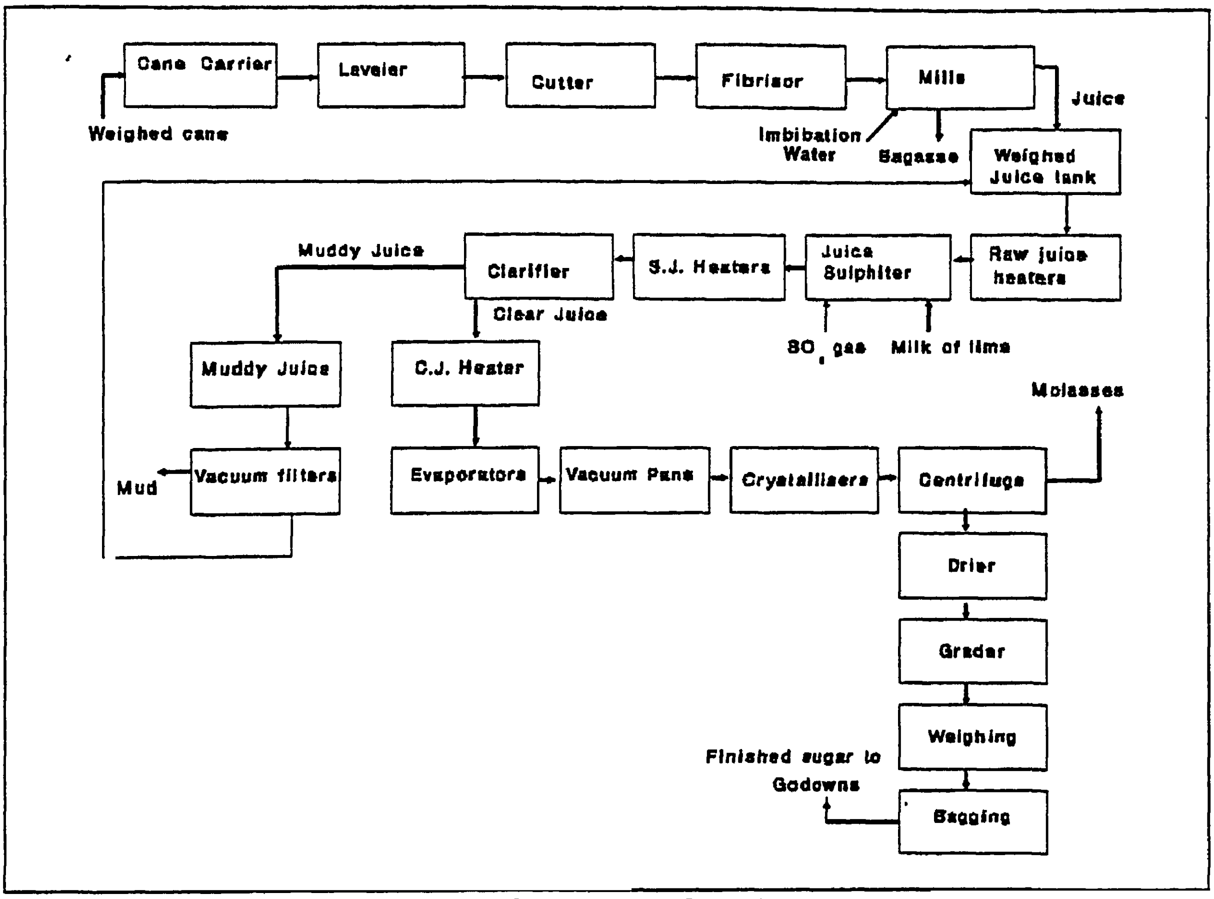


Figure 1 Simplified flow sheet of sugar manufacturing process

2.6.1 Juice Extraction

The juice extraction plant consists of cane handling, cane preparation and milling sections.

a/ Cane handling

Cane is brought mainly by trucks, trollies and bullock carts to the mill. The load is first weighed on a weighing bridge. The sugarcane is mechanically unloaded by a grab type attachment. A truck tippler is also sometimes provided to unload cane, facilitating loading of the sugar cane on to the cane carrier.

b/ Cane Preparation

The sugarcane after delivery to the cane carrier is levelled in the leveler before it is fed to the cutter. The cutter shreds the cane to smaller sizes and prepares it for the fibrisor where the cane is converted to a pulp-like mass.

c/ Milling

The prepared cane is passed through a milling tandem composed of four to six three-roller mills. The juice is extracted from the cane by squeezing under high pressure in these rollers. Extraction is maximised by leaching the disintegrated exposed cane with weak juice and make-up water in a counter current system. In the sugar industry, this leaching system is called "imbibition".

Mixed juice, which is a mixture of juice extracted normally from the first and second stage milling is fed to the next production stage. The fibrous matter or 'bagasse' which is left after milling is used as a fuel for steam generation.

2.6.2 *Juice clarification*

The purification of juice involves (a) juice heating (b) sulphitation (c) clarification and (d) filtration.

The mixed juice from the mills is heated in raw juice heater(s). The common process employed in most of the mills in India is Double Sulphitation process. The heated juice is treated with chemicals like milk of lime and sulphur dioxide gas in a juice sulphiter. Various dissolved impurities in the mixed juice are precipitated out. The impurities precipitated are separated to obtain clear sparkle juice in clarifiers. Muddy juice which settles at the bottom is filtered in vacuum filters and the filtrate is recycled back to the system. The retention time in the clarifiers is about 2-3 hours and this invariably results in an appreciable temperature drop. Hence the juice is again heated to obtain a temperature of about 105°C.

2.6.3 *Evaporation*

The juice is concentrated from 15 Brix to around 60 Brix in a multiple-effect evaporator. The vapours are bled from evaporators for juice heating in various heat exchangers and for boiling of massecuite in vacuum pans. This is the major steam consuming section of plant.

2.6.4 *Crystallisation*

Crystallisation is an important unit operation which in sugar industry is known as Pan boiling. Major part of the crystallization process is done in most of the sugar plants in batch type vacuum pans. A mixture of the molten liquid and crystals, known as "massecuite" is then transferred to crystallizers where the process is completed by cooling the mass under stirred condition.

2.6.5 *Centrifuging*

The massecuite from the vacuum pans is sent to the centrifuges, where the sugar crystals are separated from molasses. These centrifugal machines can be batch type or continuous type. There are separate centrifugal machines for 'A' type, 'B' type and 'C' type massecuites. The molasses separated out from this section is a useful byproduct which is an excellent raw material for distilleries.

2.6.6 *Drying, grading and packing*

The moist crystals obtained from centrifugal machines normally contain about 15-20% surface moisture. They are dried in traditional dryers, graded according to crystal sizes and then packed in bags.

2.7 By-products

The main by-products from any sugar industry are: (i) bagasse (ii) molasses and (iii) filter cake.

- **Bagasse:** Bagasse is an important by-product of sugar. It is rich in cellulose fibre and can be used as a major substitute raw material in the paper and pulp industry, replacing wood and bamboo, thus reducing deforestation. Costly imports of pulp and waste paper can be avoided thus conserving the outflow of foreign exchange. Bagasse has also been suggested as a base material for cattle feed after mixing with molasses in varying proportions. The other important product which can be manufactured from bagasse is furfural which is a very versatile chemical with good potential for commercial usage. Presently, almost all the sugar mills utilise this bagasse as an inhouse fuel in boilers for steam generation. Number of mills are now planning to utilise the bagasse efficiently in high pressure boilers for cogenerating electricity for export to the grid/neighbouring units. The details on cogeneration possibilities are covered separately in section 4.

- **Molasses:** Molasses, the other important by-product, is a store-house of organic chemicals. Industrial alcohol is produced from molasses which in turn can be used to manufacture chemicals like ethyl benzene, lactic acid, tartaric acid, citric acid, diethyl phthalate, etc. Industrial alcohol can be used as a fuel extender as a substitute to the scarce petroleum products.

- **Filter cake:** When cane juice is clarified and filtered, the resulting cake is known as filter mud or filter cake. It contains most of the colloidal matter precipitated

during clarification and has around 63% organic matter. This cake is of great manurial value and is mostly taken by the growers in their own transport after delivering cane to the factory, for use in the fields.

CHAPTER 3

Sectoral Energy Profile

3.1 Fuel sources

The main energy requirements in a sugar mill are steam for process heating/turbo drives and electricity for running various drives. The sugar industry has the unique advantage of utilising a captive fuel - bagasse, to meet its energy requirements. The bagasse produced as a byproduct is a renewable source of energy and is thus considered an environmentally friendly option. Bagasse, if unutilised, poses serious problems for the sugar industry. Being a low density product, it requires huge space for storage. Therefore, it is a 'win-win' situation for sugar mills to get rid of this bagasse and at the same time utilize it as a fuel in the boilers to meet the onsite energy requirements of the mill. Due to the captive fuel supply source, most of the mills are able to operate their plants at near 100% capacity utilisation. The share of energy cost in the total cost of production varies widely from plant to plant depending upon the opportunity cost of bagasse in the region. In a few specific cases studied, it was around 10-15 % of the cost of production.

Although bagasse contains 50% moisture, it has a calorific value of around 2300 Kcal/kg, making it an extremely effective energy resource. Some of the mills have arrangements to supply part of the bagasse produced to nearby paper plants as it is an excellent raw material for paper manufacture. Such plants and some of the old inefficient plants which are not able to optimize their process steam requirements partially resort to other fuel sources like coal and fuel oil. Similarly, all the mills have installed TG sets for meeting the captive power needs. Inefficient old factories also partly depend on the SEB supply. However, most of the mills have to depend on the grid supply during the off season to meet the small power needs of plant as the complete maintenance and overhauling of the plant and equipment is taken up during that period.

3.2 Absolute Energy Consumption

Generally, a sugar mill in India is self reliant in power and bagasse. However, depending upon various factors like fibre content in the cane, quantity of juice, type of clarification process and evaporation effects, type of prime movers (steam driven or electric driven) etc., some sugar mills produce a small quantity of surplus bagasse while others are deficient by a small quantity. These mills, therefore, have to depend in a very limited way on external fuels like fuel oil, LSHS etc to supplement their energy requirements. Likewise, some sugar mills during the season can produce a little surplus power while

others would be deficient in power by a small margin and hence depend upon grid power. The consumption of various petroleum products in the last five years by the sugar industry is given in Table 5. Coal consumption in the industry is negligible as the major fuel used in boilers is bagasse. The total captive installed capacity and electricity generated as on 31 March, 1993 in the 316 sugar units surveyed is given in Table 6.

Assuming that the entire bagasse generated by the industry (approximately 30% on cane) is used in the sugar industry itself, the primary energy input into the sugar sector is of the order of 100 million Gcal. However, in order to arrive at the energy consumption in the process, the average specific thermal and electrical energy consumption in the entire Indian sugar industry has been taken as 0.55 t of steam and 24 Kwh per ton of cane crushed respectively. The energy consumption in the sugar industry for 1994-95 is given below, which is an estimated figure based on the assumptions mentioned above.

Sugar production	14.5 million tonnes
Thermal energy consumption	$5.1 * 10^7$ Gcal[3]
Electrical energy consumption	3480 GWh
Total energy consumption	$5.4 * 10^7$ Gcal

Table 5. Consumption of petroleum products in the sugar industry ('000 tonnes)

	1989-90		1990-91		1991-92		1992-93		1993-94	
	Cons.	% of total	Cons.	% of total	Cons.	% of total	Cons.	% of total	Cons	% of total
HSD	69	0.3	99	0.5	96	0.4	87	0.4	84	0.3
LDO	2	0.1	4	0.2	1	0.1	1	0.1	1	0.1
FO	14	0.3	14	0.3	18	0.4	16	0.3	15	0.3
LSHS	2	Neg	2	0.1	1	Neg	Neg	-	Neg	-

Source. Indian Petroleum and Natural Gas Statistics, 1993-94

Table 6. Captive installed capacity and electricity generated in sugar mills

	Steam	Diesel	Gas	Hydro	Total
Installed capacity (KW)	660500	198352	500	700	860052
Electricity generated (GWh)	1314	380	0	0	1694

Source. TEDDY, 1995

Steam conditions: Saturated steam at 1 kg/cm^2(g)

3.3 Energy consumption pattern

The bagasse generated from the milling section is burnt in boilers. The steam produced in boilers is used for driving steam turbines to provide mechanical power, mainly in the milling section and for operating the turbo-generator sets for generation of electricity. The heat energy in the exhaust steam of turbines and the back-pressure TG sets is used in the process for concentration of juice in evaporators. Certain quantity of this steam is also utilised in juice heaters to meet the process requirements. The boiler steam pressures normally encountered in very old mills are around 15 Kg/cm^2 while it is around 21 Kg/cm^2 for the mills set up in seventies. But in the sugar plants that came up since eighties, most of the plants have put up boilers which generate steam at 32 Kg/cm^2. Very recently some of the plants have put up boilers of 42 Kg/cm^2 pressure configuration. There does not exist till now any plant in the country which employs higher pressures (in the range of 63 Kg/cm^2 or more) for generating steam. In contrast, plants in Reunion Island and Hawaii operate at very high pressures of around 81 Kg/cm^2 and thus are able to utilize the available bagasse in a more efficient manner. The shift from low pressure to medium pressure system has occurred mainly due to increasing confidence of the plant operators to handle these medium pressure systems. With the increasing costs of primary energy, there is a concerted effort to utilize the available bagasse more efficiently so that the dependence on SEB supply can be reduced to a bare minimum.

Energy efficiency of sugar plants depends on various factors such as its capacity, steam generation parameters, vintage, equipment upgradation, etc. As the capacity of Indian sugar industries varies from 400 TCD to 7000 TCD, the corresponding energy consumption vary considerably. The steam consumption in the mills varies from 45% on cane in case of very efficient mills to as high as 60% on cane in a large number of old inefficient mills. The average figure for the industry is around 55% on cane which works out to around 3500 kcal/kg of sugar. The electrical energy consumption is between 20 - 28 Kwh/ton of cane crushed. The approximate breakup of electrical and thermal energy utilisation in various sections of the plant is given in Tables 7 and 8 respectively.

Table 7. Electrical energy utilisation in various sections

Section	Energy consumption (Kwh/ton of cane crushed)
Boiler house	3-5.5
Milling section drives	5.5-8
Injection water pumps	2-3
Process area drives	2-5.5
Lighting and others	1-3

Table 8. Thermal energy utilisation in various sections

Section	Energy consumption (ton of steam/ton of cane crushed)
Turbo generator	0.3-0.4*
Mill turbines	0.15-0.2*
Other process steam requirements	Appx. 0.05

* The backpressure steam (at approx. 1 kg/cm²g) from these turbines is utilized in the process. Nearly 90% of this low pressure steam is used in the evaporators for concentration of juice and the balance 10% is utilized in various heat exchangers. The heat requirements of pans and other heat exchangers is normally met from bleeds taken from various evaporator bodies. In terms of process wise break-up, the energy consumption levels in the Indian sugar industry are

Juice heating	20-25%
Evaporation	30%
Crystallisation	35-40%
Miscellaneous	10%

3.4 Energy efficiency norms

With a view to reduce energy consumption in the sugar industry, the Government of India in 1988 introduced norms for energy efficiency. These norms require that all sugar factories (expanded on the basis of 1973 standard specifications) set up prior to 1977 should have a maximum steam consumption of 55% while the new factories (set up on 1987 standard specifications) should have a maximum steam consumption of 50%. These norms shall not be applicable to factories set up prior to October 1960 and having a daily cane crushing capacity upto and including 1000 TCD till such time such factories are expanded / modernized to the minimum economic capacity of 2500 TCD prescribed by the Government of India. The factories have also been advised to install appropriately calibrated steam flow meters and water flow meters so as to facilitate assessment of total steam consumption with a reasonable degree of accuracy.

3.5 Policies for modernisation and rehabilitation of sugar factories

Sugar Development Fund set up under the Sugar Development Fund Act, 1982 provides for sanctioning loans to sugar industries for rehabilitation of plant and machinery. The Fund helps financially weak and old sugar undertakings to obtain financial assistance from specified Institutions for modernisation. The detailed guidelines for the purpose can be obtained from the Ministry of Food, Government of India. SDF is funded by the transfer of proceeds of sugar cess levied (Rs. 14/- per quintal presently) and collected under the Sugar Cess Act, 1982 on the sugar produced in the country.

CHAPTER 4

Energy conservation opportunities

The energy consumption in Indian sugar industry is high mainly because of (i) the presence of a large number of small sized old inefficient mills (ii) not-so-modern technology governing process operations and (iii) non-incorporation of energy saving devices and inadequate implementation of energy conservation measures. The scenario can be improved by optimising the process steam requirements, upgradation of steam generation parameters for adopting advanced cogeneration systems and employing energy efficient technologies in various sections of the plant. The energy saving opportunities available to the Indian industry have been discussed under two heads, namely

* Adoption of advanced cogeneration systems
* Energy conservation measures in the process

This categorisation has been intentionally done to emphasize the importance of cogeneration in the sugar industry. The benefits of adopting cogeneration not only accrue to the sugar mills but more importantly, it is 'the greener' option of generating electricity to bridge the ever widening gap between demand and supply of power.

4.1 Adoption of advanced cogeneration systems

Cogeneration is the concurrent production of electricity and process heat in a single integrated utility system. The concept is not a new one, but in recent years it has attracted renewed interest due to the rising prices of inputs. Bagasse based cogeneration in the sugar industry is an option which offers tremendous advantages. In the Indian sugar mills, bagasse is burnt in low pressure boilers to generate steam so as to produce electricity for meeting the captive power needs of the plant. Instead, if this bagasse is burnt in an efficient manner to generate high pressure steam, it would be possible to produce electricity which is far in excess of the onsite power requirements of the plant and can be fed to the grid. It would thus be possible to produce this excess electricity without emitting any additional carbon dioxide. Even otherwise, bagasse being a biomass, the net carbon emissions from the use of this bagasse as an energy source can be considered to be zero and can save up to 1.2 kg of CO_2 per kWh of electricity generated.

4.1.1 Present Status of Cogeneration in Indian Sugar Industry

The concept of cogeneration of power and steam to meet the internal needs for the sugar factory is inherent in the sugar process itself. The location of the sugar mills in rural areas far flung from the grid power, the availability of byproduct fuel i.e. bagasse and the process steam requirement at lower pressures all led to the adoption of this concept of cogeneration in a limited way by the industry. By generating captive power, the mills were able to insulate themselves from the vagaries of the State Electricity Boards (SEBs). Moreover, bagasse based power proved to be much cheaper than the price which the sugar mill owners would have to pay to the SEBs. However, till now almost the entire Indian sugar industry has not pursued the goal of properly tapping the vast cogeneration potential existing in the factories. Cogeneration for the sugar mill should actually mean making optimum use of steam generated from boilers i.e. producing maximum power out of the steam before it is supplied to the system for process heat requirements. The surplus power generated can be supplied to the ancillary units/neighboring factories or fed to the grid. Existing sugar mills in India produce 30% wet bagasse based on cane crushed which has a moisture content of around 50%. This bagasse is mainly consumed in small bagasse fired steam turbine systems utilising steam at 15-25 kg/cm^2 which is just enough to meet the onsite steam and electricity needs of the plant. A typical 2500 TCD mill produces 64 TPH steam at 22 kg/cm^2 and 330 °C which is used partly in drives for the mills and balance for generating approximately 2.5 MW power through a back pressure turbo-generator set for captive use. The process steam requirement in Indian mills is normally 500-550 kg of steam per tonne of cane crushed. In fact, it can be said that the factories which are existing today have been designed to be somewhat inefficient, consuming all the available bagasse so that it does not accumulate while just meeting the electric and steam needs of the plant. The existing boilers in the sugar mills are in a way acting as incinerators to dispose off bagasse rather than act as boilers to generate steam and electricity effectively.

The sugar industry is a seasonal industry with the sugar season lasting for nearly six months in a year. Hence, the boilers in use are designed to use only one fuel, viz. bagasse which is available as a by product in the crushing season. If these mills have to be operated in the cogeneration mode, it would be worthwhile to run the plant in the offseason also with certain other fuel, e.g. coal, lignite or other biomass fuels - depending upon the location of the mills and hence the need to install multifuel high pressure boilers. A few indigenous manufacturers claim to have developed the capability to manufacture fluidized bed boilers operating at 63 kg/cm^2 pressure with bagasse as the primary fuel. Of course, no such boilers have yet been supplied to any of the sugar mills. Thus, it can be said that the indigenous capability to manufacture bagasse based boilers that can generate steam at pressures of 63 kg/cm^2 or 81 kg/cm^2 for use in sugar mills is limited.

Most of the existing turbines used in the industry are backpressure type exhausting steam at around 1 kg/cm²(g). These turbines have been supplied mainly by indigenous manufactures and conform to specifications as laid down by the National Federation of Cooperative Sugar Factories Limited. For generating 10 MW or more of the power and to ensure effective utilisation of the cogeneration system in the off season, it would be better if schemes with energy efficient double extraction condensing turbines can be adopted. This would thus ensure high efficiency of power generation due to the elimination of pressure reducing valve stations.

4.1.2 Possible modes of cogeneration

Cogeneration systems which can be installed in the sugar plant can be broadly classified in three categories as follows:

(i) Extraction-cum-back pressure route

In this system, the quality of steam produced is as required for the process. By upgrading the steam parameters, it is possible to generate surplus power even after meeting the captive power demand. With this system, power is generated only during the crushing season. The extraction-cum-back pressure cogeneration system is the cheapest from the point of view of the initial capital cost. However, it suffers from the drawback of surplus power fluctuations resulting from fluctuations in the process steam requirement. Recommended steam parameters for the techno-economic feasible operation of this system are, 63 kg/cm^2 pressure and 480°C temperature.

(ii) Extraction-cum-condensing route

Here, the entire bagasse production of a sugar mill is used for steam generation at 63 kg/cm^2 at a temperature of 480°C and the power is cogenerated using an extraction-cum-condensing TG set. In addition to supplying power during the crushing season, it may be extended to off-season months by purchasing surplus bagasse from nearby sugar mills or by using the bagasse saved during the crushing season. The capital cost as well as cost of electricity generated in this mode is likely to be higher than the extraction-cum-back pressure route. However, this mode has the potential to supply stable surplus power for a longer period.

(iii) Condensing route based on dual fuel system

This mode of cogeneration has the facility of round the year stable surplus power supply by using alternative fuels such as natural gas, coal, lignite or biomass based fuels like rice straw/husk, wood plantations etc. during the off-season. It may be economically more

viable to install duel-fuel boilers by sugar mills, which are located near the source of the alternate fuel. The capital cost of the multifuel system, particularly, while using coal as the support fuel would be higher along with the associated problems of pollution control and ash disposal. As this system incorporates advanced technology of higher steam parameters, it requires highly trained/skilled manpower for its operation and maintenance. This model may be more appropriate for bigger size sugar plants, typically of the order of 5000 TCD.

Carrying out a detailed techno-economic feasibility study may be desirable in each case to decide the operating parameters and the cogeneration scheme best suited for a plant. Depending upon the condition of the boilers and turbines existing in the plants, the steam consumption patterns and other parameters like plant layout, plant expansion plans etc., various configurations of cogen packages can be considered. Some of these are mentioned below:

1) Retaining low pressure boiler(s) and replacing the milling turbines by hydraulic drives/electric motors.
2) Replacing low pressures boilers with boiler(s) of 43 kg/cm^2, 480°C and turbine(s) (back pressure extraction or condensing) to match the steam parameters
3) Replacing low pressure boilers by new boiler(s) / TG set(s) of 63 kg/cm^2, 480°C and all electric drives.
4) Replacement of low pressure boilers by new boiler(s) / TG set(s) of 81 kg/cm^2, 520°C

The mills can adopt any of these cogeneration schemes and each one of these can have various possible configurations within itself. Since all these schemes are technically feasible, the choice would essentially depend upon the level of confidence of the plant managers in operating the high pressure systems and the capital which the plant management can afford to put into the system.

4.1.3 Potential of Biomass based Cogeneration

Ministry of Non Conventional Energy Sources, Government of India (GOI) constituted a Task Force on Biomass Cogeneration in 1993 to assess the biomass based cogeneration potential in the country and suggest means to tap this potential. This Task Force estimated the potential of surplus power generation as 3436 MW by the end of the Eighth Plan (1996-97). This potential was based on the assumption that the total number of equivalent 2500 TCD plants in the country in 1996-97 will be 358 and all these plants adopt steam

parameters of 65 kg/cm^2 and 480 °C and the power is generated through extraction cum condensing route with no surplus bagasse.

The potential of surplus power generation in Indian sugar industry as estimated by the Task Force and corresponding assumptions made for arriving at this potential are given in Table 9. As can be seen from this table, the cogeneration potential would be higher in case the steam consumption is reduced to 45% or less. Various energy cogeneration schemes (as outlined in section 4.2) can be implemented in the plants so as to bring down the steam consumption and thus make available additional steam for maximum power generation.

4.1.4 Benefits of Biomass based Cogeneration

There are two major advantages of installing biomass based cogeneration systems - (i) energy savings and (ii) the associated financial benefits. These are briefly discussed below:

i) Energy Savings

Conventional systems producing energy for process heat convert approximately 60-70% of the fuel energy to useful work. Conventional electricity generating systems on the other hand, have an average efficiency of only around 35%. Using cogeneration rather than separate systems, to produce heat and electricity will yield efficiencies of the order of 80%. Thus, cogeneration can help the country in improving the utilization efficiency of energy and in reducing the consumption of depletable fossil fuels.

Table 9. Cogeneration potential of surplus power in sugar industry in India

Year	Total cane likely to be crushed (10^5 tonne)	Equivalent standard 2500 TCD sugar factories (number)	Steam consumption (% of cane)	Surplus cogeneration in 2500 TCD plant (MW)		Surplus cogeneration in industry (MW)		Total cogeneration potential in industry (MW)
				*	**	*	**	
1994-95#	1341.3	325	50	6.5	2.6	2112	845	2957
			45	5.5	4.1	1787	1332	3119
1995-96	1408.4	341	50	6.5	2.6	2216	886	3102
			45	5.5	4.1	1875	1398	3273
1996-97	1478.3	358	50	6.5	2.6	2327	930	3258
			45	5.5	4.1	1969	1467	3436

* Potential of surplus power generation through extraction cum back pressure route with 5 to 7 per cent cane saving in bagasse.
** Potential of additional surplus power generated through condensing route with no surplus bagasse.

The assumptions for the data in the table are as follows:
(1) Average working season - 165 days;
(2) Power is generated during crushing period only;
(3) All the sugar plants adopt steam parameters of 65 kg/cm^2 at temperature of 480°C;
(4) Total number of licensed sugar plants considered is 396 but for simplification of calculation an equivalent 2500 TCD has been considered;
(5) The surplus power for export given above is in additional to the captive requirement of about 3.5 MW by each sugar plant.
\# As estimated by the Task Force in 1993

Source. Abbi etal,1994

As mentioned earlier, sugar mills in India are having low pressure boilers with back pressure turbines. To derive maximum benefits from cogeneration, shift to high pressure systems employing extraction condensing turbines is a must.

(ii) Financial Benefits

For a given amount of electric and heat power output, the capital and operating costs of cogeneration are generally less than the corresponding costs of separate conventional systems. Capital costs per unit of useful energy associated with cogeneration would be lower than the conventional electricity generating systems. According to the estimates of NFCSF, an incremental investment of Rs 23 crore is required for a cogeneration scheme in power maximisation mode (at 65 kg/cm^2 steam parameters) for a standard new 2500 TCD sugar plant, resulting in 9 MW of surplus exportable power for 150-180 days in a year. An illustrative capital cost breakup (as given by NFCSF) is given in Annexure V. These costs compare very favourably when compared with the capital costs for a new thermal power plant which are in the range of Rs 4 to 4.5 crore/MW. The operating costs will also be substantially lower than conventional plants because the raw material costs viz. bagasse can be taken to be available at sugar plant site as a byproduct of sugar manufacture. Even otherwise, the cost of bagasse would be lower than the landed price of coal, oil or gas at a large number of locations. Similarly, there would be reduced transportation costs as the bagasse would be available on site during the season while in the off season, the mills can explore the possibility of using locally available other biomass fuels like rice husk, field trash, etc. and even fossil fuels like coal and lignite, if the same are available within reasonable distance. This would also reduce the burden on the already overstrained railway network of the nation. Payback periods are extremely attractive especially when the cogeneration plant is operated during the off season also. As electricity prices rise, cogeneration would offer increasing savings.

For the sugar mills, these advanced cogeneration systems offer a very a good business opportunity to venture into the field of electricity generation and it can help them improve their financial health. If the mills opt for multifuel boilers, it opens up the field for revenue flows for the sugar mills in the off-season also. This would be a welcome option for the plant management because their large capital can be effectively utilized which now remains unutilised for nearly six months in a year.

Bagasse based cogenerators feeding to the grid can **help in meeting the growing power demand of the country**. India is experiencing rapid growth in the demand for electricity and is projected to face an annual average growth rate of approximately 7 percent over the next decade. This challenge is compounded by the fact that India currently is facing acute shortages in meeting its growing demand. Establishment of

biomass based cogenerators which can export power to the grid would help in reducing this ever widening gap between the demand and supply of electricity in the country. Such plants can also be justified from the viewpoint of **social benefits** accruing to the nation. The use of bagasse for cogeneration would provide local benefits like additional employment in the rural areas, additional power injected into the rural grid and the potential for attracting other rural industries that rely on reliable electric power. Setting up cogeneration plants in these far-flung sugar plants which are normally not in the industrial zones, would help upgrade the living standards of rural people living in the vicinity of these plants. This is so because the plants can continue to be in operation throughout the year as they will be generating power for the purpose of export during the off-season.

4.1.5 Constraints to Cogeneration

Although the Indian sugar industry is in existence for a long time, commercial cogeneration has not taken off due to a number of reasons. Some of the major constraints are highlighted below:

(i) Policy and regulatory constraints

One of the main reasons which is often given for the cogeneration not taking off in the Indian industry is the unwillingness on the part of the SEBs to purchase the electricity from the sugar mills at attractive rates. From a particular utilities point of view, the power produced by the cogenerator for feeding to the grid is, ofcourse, of insignificant magnitude as compared to the operation of the grid. However, the combined effect of these small power producers can add up to a significantly large generation capacity for the nation. Absence of any policies which encourage the sugar mills to cogenerate had really been one of the most crucial factors in inhibiting commercial cogeneration in the Indian sugar industry. The US example of PURPA is worth mentioning here because it was this Act which made it mandatory for the US utilities to buy power from the cogenerators at 'avoided costs'. Avoided cost is the added cost to the electric utility that the utility will either generate itself or purchase elsewhere if it did not purchase from the cogenerator. But now, some of the SEBs have come out with schemes to encourage commercial cogeneration which offer attractive buyback rates and also allow wheeling, banking and third party sales. However, some of the mills have expressed the views that the policies announced by a few SEBs recently do not clearly state many issues like buy back rates, installation of transmission lines from the mills to the substation, cost of the substation and a few other related matters. These issues would need to be resolved to encourage the mills to adopt cogeneration systems. It is worthwhile to mention here that it was solely the

positive attitude of TNEB which prompted a few sugar mills in Tamil Nadu to put up cogen plants in their factories.

It is, therefore, important that the utilities must consider cogeneration option as a source of firm power supply and should also consider the environmental and social costs of conventional power vis-a-vis the cogenerated power while carrying out their long term planning exercise. Pricing policies must be seen to be reflective of economic long run marginal costs of power production and to be guaranteed from fluctuations due to political and other non economic considerations.

(ii) Institutional constraints

As mentioned earlier, SEBs have to play a very important role in promoting the cogeneration schemes in the sugar industry, especially in terms of the tariff rates for buy back of power, provision of wheeling and banking of power and consequently working out power purchase agreements which would be attractive for the potential cogenerators. The importance of SEBs assume greater significance considering the fact that large proportion of the investment may come from channels like foreign direct investment and the investors would require firm commitments in terms of their returns on the capital invested. Therefore, it can be said that a clear legal framework is a prerequisite for ensuring adoption of commercial cogeneration. A uniform policy of having long term power purchase agreements(PPA) at remunerative prices between the SEBs and the cogenerators would encourage the sugar mill owners to put cogeneration facilities.

(iii) Financial constraints

Investments required for setting up cogeneration plants are substantial, sometimes even more than the capital required to set up a new sugar mill. Given the scarcity of capital in India coupled with the increasing demand of sugar, the mills tend to select their investments based on the financial rates of return of competing investment options.

However, with the opening up of the Indian economy and a number of liberalisation measures initiated by the Government of India in the last two years, it can be expected that financial resources from foreign partners would be forthcoming provided the regulatory and policy framework is favourable for installing cogeneration systems in the sugar mills.

iv) Technological constraints

The technical issues concerning installation of a commercial cogeneration project center on determination of potential, detailed system engineering, selection and procurement of the plant and equipment and operation of the cogeneration plant.

The determination of the cogeneration potential in the sugar plant is a fairly straight forward process and the Indian sugar industry personnel and the Engineering Consultancy firms engaged in business are competent enough to handle this aspect. Similarly, the detailed system engineering for installing the plants can be done indigenously. It is with regard to the availability of high pressure energy efficient boilers and turbines for the cogen plants that the indigenous capabilities are limited. Regarding the installation and commissioning of the cogeneration plant, the Indian sugar mills also encounter a typical problem which is connected with their being old and obsolete. Partial modification of their plants will not be justified. Since a large number of sugar mills have expanded in stages, the layouts sometimes have become very complex. Any cogeneration project envisaged in such plants would require a comprehensive study of the existing plant and machinery and plant layout so that it justifies the large investments required for cogeneration facilities.

Another related problem pertains to the synchronization of the cogenerator with the grid. These include safety, power quality, reliability, protection of transmission and distribution facilities, grid interfacing and dispatching problems. The utilities must maintain the integrity of their systems in order to ensure a reliable supply of electricity to their customers. Therefore, any interconnected cogeneration system must include equipment dedicated to protecting both the utility and cogenerator from problems that may originate from the grid or the cogeneration system. There may also be problems of grid synchronization when the electricity cogenerated is at 11 KV while the grid may need it to be fed in at 33/66 KV. In order to protect the cogenerator as well as the interconnecting distribution system, it will be essential to provide for suitable over and under frequency protectors and over and under voltage and current protection devices.

v) Lack of information

The Indian sugar industry does not have easy access to any scientific and detailed information on the different types of cogen systems available around the world from various manufacturers of boilers and turbines. There is also a scarcity of information on the performance characteristics of operating cogen systems in other countries and as a result, this leads to a reluctance on the part of potential cogenerators to adopt the technology.

4.1.6 Recent initiatives to provide bagasse based cogeneration

The Government of India, under the Ministry of Non-Conventional Energy Sources, vide their circular dated 5th January and 7th January 1994 announced financial incentives for demonstration cogeneration projects in sugar mills and for the preparation of Detailed

project reports for bagasse based cogeneration. These schemes were recently revised by the MNES based upon the feedback received from various quarters. The circular dated 8 August 1995 from MNES gives in detail the various schemes under the Ministry's National Programme on Bagasse based Cogeneration.

Various other initiatives have been taken by the Ministry of Power and the respective State Electricity Boards to formalise mechanisms for buy back of power as well as for wheeling/banking/third party sales.

4.2 Energy Conservation Measures in the process

Study of present energy consumption patterns in existing sugar plants reveals that there is a considerable scope for reducing energy consumption in the mills. The process steam in the sugar plants is normally required at 1 kg/cm^2(g) while a small quantity (approximately 6-10 % of the steam generated) is required at medium pressures (around 6 kg/cm^2) for sulphur melting and in a few other sections of the plant. The live steam is generated at different pressures (11 to 42 kg/cm^2) in different plants and fed to the turbines. The 1 kg/cm^2(g) process steam from the exhaust of the prime movers is mainly used in the evaporator section for concentrating of the clear juice. Bleeds from the evaporators are normally used in pan boiling for crystallization and in various heat exchangers to meet the process heat requirements.

The importance of steam economy in the sugar manufacture cannot be ignored because lesser the steam required for process, the more of it will be available for electricity generation. However, it is very important to realise that it would be pointless to reduce the process steam consumption below the level of exhaust steam generated by the prime movers. Infact this has been one of the reasons for the lack of any real efforts on the part of the sugar mill owners to invest in technologies/ equipment which lead to reduction in demand of exhaust steam. In order to achieve a proper balance between the exhaust steam and process steam, the extraction condensing turbines become necessary. If such turbines are in place, the moment exhaust steam tends to become surplus, it can be diverted to the condensing side so that electrical energy can be produced. Therefore, to derive maximum benefits from reducing steam demand in the sugar manufacturing process, commercial cogeneration must be pursued simultaneously. Experience of sugar mills operating in Hawaii and Mauritius clearly points out that it is possible to save energy considerably in the process and thus make available surplus energy in the form of bagasse or electricity. Table 10 shows the bagasse savings that are possible at various levels of steam consumption in the mills.

Table 10. Bagasse savings at different levels of steam consumption

Steam consumption (t/t of cane)	Heat energy in process steam (kcal/t of cane)	Bagasse consumed for process heat (t/t of cane)	Bagasse saved (as % of bagasse consumed in base case)
0.55 (Base case)	306020	0.22	-
0.50	278200	0.20	9.1
0.45	250380	0.18	18.2
0.40	222560	0.16	27.3

Various energy conservation measures that can lead to reduction in steam demand are given in the following paragraphs. These options can help in reducing the overall process steam demand from the base case 55% on cane to around 45% on cane (which works out to a conservation potential of nearly 20%)

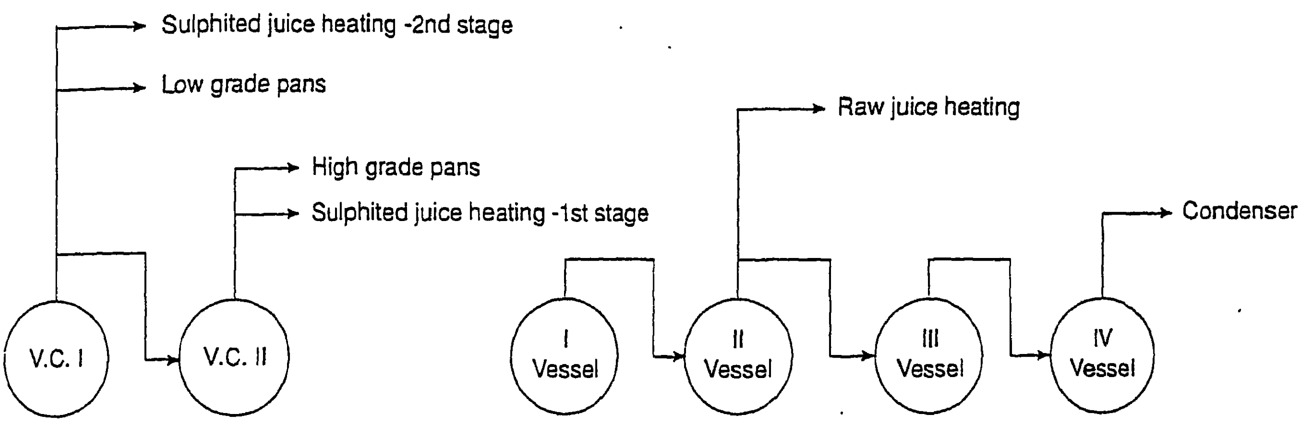
4.2.1 Steam economy in the evaporator station

The concentration of clarified juice from 15 Bx to around 60 Bx is done in multiple effect evaporators as a first step towards crystallization. The underlying principle in these multiple effect evaporators is that exhaust steam is used only once and the vapours produced by the boiling juice are used repeatedly for further boiling the juice in the subsequent vessels. The evaporator station also acts as a source for providing heat energy for the heating of the juice in heat exchangers and for crystallization of the sugar in the vacuum pans. Various configurations of evaporator arrangements/ bleeding schemes are possible to achieve the above objective.

(i) Modifications in the bleeding schemes

The vapours from the first effect having higher temperatures can be used profitably for heating the sulphited juice, clear juice and for boiling requirements in the pans. Vapours from the second effect having comparatively lower temperatures can be used for raw juice heating. Introduction of vapour cells or pre-evaporators has been found useful in reducing complexities associated with bleeding of vapours from several bodies and more so, in effecting steam economy in the evaporator section. The vapours from the vapour cell can be completely used for pan boiling and juice heating. The 1987 standard specifications for sugar plants have recommended the use of double effect vapour cells and a quadruple arrangement. In this arrangement, the vapour cell I is designed to bleed vapours to low grade vacuum pans and second stage heating of sulphited juice. The vapour cell II is designed to bleed vapours to high grade vacuum pans and first stage heating of sulphited juice. The total process steam consumption in such an arrangement is estimated to be 44% on cane. Figure 2 shows the schematic of this scheme. However, it may be noted that this

is just one of the configurations; various combinations of vapour bleeding schemes can be analysed to identify possibilities of energy savings.



Total process steam consumption = 44% on cane

Figure 2: Configuration of a bleeding scheme in evaporater section

Source: DST, 1990

Possibilities to effectively recover the heat in the condensate like feed preheating, preheating of intermediate liquid streams using condensates from the preceding effects and use of condensate flash tanks can also be explored on a case to case basis. When using flash tanks, the condensate from each effect is allowed to flash into the vapour line of the following effect. The steam generated by this flashing is then used for further evaporation. The quantity of flash steam generated is a function of the pressure differential between the condensate pressure and flash tank pressure. Introduction of these additional vapours to the evaporator bodies will increase the heat transfer to the evaporating liquid in the tubes. Normally, the evaporator bodies existing at plants would be able to handle the flashed vapours and there would not be much variation in the temperature profiles within the various effects.

Calculations done for a typical case to determine the reduction in steam consumption achievable by installing flash vessel for the first effect condensate shows that it is possible to reduce the consumption by 1.6% on cane for achieving the same concentration of the liquid at the outlet of the evaporator (as in the base case). Similarly,

calculations for a particular plant showed that by employing a plate type liquid - liquid heat exchanger which uses Ist effect condensate as the heating medium, it is possible to reduce exhaust steam consumption by 2 % on cane.

(ii) Adoption of falling film evaporator

Falling film evaporator is usually a conventional 1-1 exchanger designed to operate vertically. The liquid solution enters from the top at such a rate that the tubes do not flow full of liquid, but instead, liquid descends downwards along the inner walls of the tubes as a thin film.. Vapour evolved from the liquid is carried downwards with the liquid, and leaves from the bottom of the unit. In appearance, these evaporators resemble long, vertical, tubular exchanger with a liquid vapour separator at the bottom and a distributor for the liquid at the top. The two main advantages are high heat transfer rates and minimal internal pressure drop.

Since a large number of mills are planning to increase their installed capacities, one of the cost effective ways to achieve the dual objective of better steam economy and increase of throughout in the evaporator section would probably be to add a first evaporator as a falling film evaporator. The concentrated juice from this evaporator body which can be falling film evaporator can thus be fed to the existing evaporator setups to continue further evaporation. Since a falling film evaporator requires a very small temperature differential. it is normally possible to accommodate an additional first effect without having to increase the pressure of steam available for heating the first body.

(iii) Evaporator Automation

Presently, the operation of evaporators is controlled manually which results in erratic performance. Variation in concentration of syrup in the evaporators can lead to major imbalances in the process steam consumption. The automatic control of evaporators can, therefore, be designed in such a way that the syrup leaving the evaporators is at a predetermined consistency. The time lag between the admittance of the steam in the first body/ vapour cell and the exit of the concentrated juice can be taken care off by the control system. The system should also take care of the controls at the other equipments like pans and heat exchangers which are linked to the evaporator station. The steam savings through automation is difficult to quantify but it is expected to be quite substantial.

4.2.2 Continuous vacuum pans for massecuite boiling

After concentration of juice in multiple effect evaporators, the subsequent process to turn the thick juice into crystal form is accomplished in the vacuum pans. The use of batch

type vacuum pans in most of the mills results in considerable fluctuations of steam consumption and irregular sugar quality. It results in variation in syrup brix of about 4-4.5 Bx. The batch pan boiling destabilises the continuous process in other stations and imbalances steam balance of the plant. The use of fully auto-controlled continuous pan has many advantages over the conventional batch pans. It helps in maintaining a steady consumption of vapours thus eliminating the problems associated with fluctuating vapour flows. Accordingly, there will not be any variations in the syrup brix. This ensures the uniform functioning of the evaporator station and also boiler steam generation. This system automatically manages the steady conditions for development and uniform growth of crystals eliminating the uncertainties of human operational errors.

The use of continuous vacuum pans would also help in reducing the heat losses which take place in the syrup storage tanks before the vacuum pans. Since pan boiling is a batch operation, there is a residence time of about four hours of the syrup in the storage tanks. If the tanks are not insulated, it would lead to significant quantity of heat losses from the vessel walls.

The main advantages of continuous pans thus are steam saving, uniform crystal size and ease of operations. A large number of continuous pans are in operation in sugar factories in Thailand and Mauritius and these designs can be suitably modified for use in Indian mills. Already, some of the Indian mills have installed such pans. One of the Indian suppliers of continuous pans claims that replacing batch pans of A, B and C massecuite would result in a steam saving of about 5% on cane in the sugar mills.

4.2.3 Energy saving measures in the milling system

The sugarcane after getting finally prepared is passed through a set of 3 or 5 roller cane mills. The mills are used for extracting the juice from the prepared cane. Most of the sugar plants have steam turbines as mill drives. The mill drives consume fairly large quantity of energy in the form of steam. The steam consumption of single stage steam turbines is of the order of 16-17 kg/kwh at a steam inlet conditions of 30 kg/cm^2 and 370 °C and a back pressure of 1 kg/cm^2(g). Nearly 30% of the steam generated is consumed by the mill drives in a sugar plant. The speed is reduced from around 1000 rpm to 3-6 rpm mostly using spur gears and thus a lot of energy is wasted. There are a number of advantages if electric motors are used as mill drives instead of using steam drives. The main advantages being higher efficiencies, easier control of the mills, easier starting/stopping, lesser maintenance needs and lesser space requirement. But even the electrical drives cannot avoid the energy wastage associated with the heavy speed reduction. With the development of gearless hydraulic drives, it has been possible to considerably reduce the energy losses associated in mills.

(i) Hydraulic drives

The hydraulic drive system is a novel development which eliminates the power losses associated with conventional reduction gear systems. This system is also referred to as 'gearless drive' system because gears which are common to the milling systems in any conventional sugar mill are completely eliminated. The power transmission efficiency of the conventional reduction gearing system having steam turbines as the prime mover is 35-45% whereas while using the hydraulic drives, an overall efficiency of 80% can be realised. A case study which shows the savings achievable by installing these drives in a typical 3500 TCD plant is given below :

Case study

Assuming that the power requirement per mill is around 240 KW/mill in a 3500 TCD sugar plant, the hydraulic drive system would consume approximately 315 KW/mill (taking 80% efficiency of the hydraulic transmission system and 95% efficiency of pumps driven by fixed speed AC motors). As a comparison, the power consumption in the existing steam driven reduction gear systems in sugar mills is around 520 KW/mill (assuming 66% efficiency of the reduction gear system and 70% efficiency of the steam turbine). This results in a saving of 820 kW for all the four mills in the milling house of a 3500 TCD plant. However, the maximum benefit of installing hydraulic drives in the milling trains would be realised if the sugar mill plans to set up commercial cogeneration plants. The steam (and thereby bagasse) saved by replacing the steam drives with hydraulic drives can be effectively used to generate electricity in the new turbo-generator sets. As an example, if the plant puts up a TG set which operates in condensing mode (inlet conditions -80 kg/cm^2 and 482 °C), it should be possible to generate around 3300 KW of electricity (assuming ASR of 16 kg for the existing back pressure turbines and 7 kg for the TG set used in the condensing mode; number of mills - 4).

4.2.4 Bagasse drying

The drying of bagasse is one of most attractive options for energy conservation in the sugar industry. This is now a well proven and patented technology abroad. Bagasse drying using flue gases from the boilers presents a special challenge because of the low level of heat energy in the flue gases, their high moisture content and the variability in terms of moisture content of bagasse and the bagasse production volumes. Also, the exit temperature of the flue gases should not be allowed to fall below the dew point since condensation of water vapours contained in the gases can lead to severe corrosion problems in the dryer, cyclones, ducts, etc. The success of any drying system therefore depends upon the level of automation and controls employed to take care of the different

variables. Bagasse drying becomes essential incase it is stored for offseason requirements. It has been found that it is possible to dry all the bagasse generated in the plant to a moisture content of 30% to 40% by utilising the waste heat in the available flue gases. The advantages associated with drying are higher flame temperatures, lower volume of the gases, lesser amount of water vapour in flue gases and lower velocities of gases which ultimately lead to higher boiler efficiencies. It has been found that boiler efficiency increases by about 5% when the bagasse is dried from 50% moisture to 40% moisture. It has been found in a typical case that there is a net energy gain of around 100 Kcal/kg of bagasse by drying the bagasse from 50% moisture to 40%.

4.2.5 Energy saving measures in the centrifuges

Centrifugal machines are used for separation of sugar crystals from the mother liquor. These machines run at high speeds and consume substantial quantity of electrical energy. Some possible energy saving options in the centrifuges are discussed below:

(i) Replacing pole changing motors with variable speed drives in batch centrifuges

Most of the sugar plants have batch centrifuges which require frequent starting and stopping. These are driven by pole changing AC motors. The electrical energy consumption in batch centrifuges can be substantially reduced by changing the pole changing AC motors with variable speed drive motors (AC or DC) with facility for regenerative braking. The AC frequency controlled drive saves 25-30% of the electric energy as compared to the pole changing motor. Moreover, during the pole changing operation, the motors draw a large current of upto 6 to 7 times the rated current. This increases the energy consumption per cycle and demands a higher limit on the peak power requirements. The other advantages of variable speed drive over the conventional drive (pole changing AC motors) are;

- smooth acceleration and braking (less wear of mechanical parts)
- low maintenance cost
- minimal reactive power requirement
- minimal line current load because of the absence of starting and switching current peaks
- low noise level
- better power factor

(b) Use of continuous centrifuges

The use of continuous centrifuges for 'B' and 'C' grade massecuites can result in major energy savings. A large number of plants have already started using continuous centrifuges

for low grade massecuites. Other mills which still use batch centrifuges can plan to shift to continuous machines due to the various advantages associated with these machines. In continuous centrifuges, the massecuite is fed continuously and the cured sugar also gets discharged continuously at high speed. Therefore, it avoids wastage of both time and power in frequent stopping and starting the machine and in charging and discharging it. The use of continuous machines has not found favour for the curing of 'A' grade massecuites because it results in damage to the crystal surface which is considered detrimental to the sugar quality. However R&D efforts are on to modify the designs so that they can be used even for high grade massecuites.

4.2.6 Other energy saving opportunities

In addition to the specific recommendations discussed above, a number of energy saving opportunities of general nature can be implemented in the steam generation section. Typical examples of such measures are heat recovery units (economisers and air preheaters), use of variable speed drives for fans and dampers, boiler automation and control systems, and controlling excess air levels.

CHAPTER 5

Environmental aspects

There are basically two sources of pollutants from the sugar plants - one caused by flue gases from the boilers and the other caused by the wastewater discharged from the various sections of the plants.

5.1 Air pollution

The total number of boilers in the Indian sugar industry is around 1100, which use bagasse as the primary fuel. Generally these boilers employ step grate/ horse shoe/ spreader stoker type furnaces with natural/induced/balanced draft. As the sulphur content of bagasse is almost nil and since the combustion temperatures are in the range that does not promote formation of oxides of nitrogen, the SO_2 and NO_x concentrations are well within the limits. There was no MINAS for particulate emissions from bagasse fired boilers till 1993 and most of the Pollution Control Boards had stipulated their own standards which were different in different states (Table 11). However, limits for SPM have now been set by the Ministry of Environment and Forests, Government of India vide the Gazette Notification dated 19 May 1993. The limits are different for different type of boilers (Table 12) and the State Pollution Control Boards have the authority to make the standards more stringent for their respective states.

Table 11. Emission limits for SPM as prescribed by State Pollution Control Boards (effective till May 1993)

States	Uttar Pradesh	Haryana	Gujarat	Tamil Nadu	Karnataka	Maharashtra
SPM concentration (mg/Nm^3)	200	600	250	200	350	115

Table 12. Emission standards for particulate emissions from bagasse fired boilers

	Step grate	Horse shoe/Pulsating grate	Spreader stoker
SPM concentration (mg/l)[4]	250	500	800

Note: In the case of horse shoe and spreader stoker boilers, if more than one boiler is connected to a single stack, the standard shall be fixed based on added capacity of all the boilers connected with the stack.

Value normalized at 12% CO_2.

The uncontrolled particulate emissions from the bagasse fired boilers in the Indian sugar industry are normally in the following ranges:

Natural draft boiler	200-500 mg/Nm^3
Induced draft boiler	1000-2000 mg/Nm^3
Balanced draft boiler	2000-5000 mg/Nm^3

The particle size of flyash from bagasse fired boilers is quite small and the particles are very light. While some of the boilers installed in newer mills have installed certain control equipment, their effectiveness and efficiency are yet to be established mainly because of the lower density of the ash. It may be possible that the emissions from new boilers might be even more than the older boilers, due to the emphasis on higher combustion rates which results in higher entertainment of ash in the flue gases. The control equipment being used presently are either multiclones or wet scrubbers which are available in different configurations. The efficiencies under actual field conditions of these equipment vary between 50 and 95% with outlet dust concentration in the range of 100-800 mg/Nm^3.

5.2 Water pollution

In any sugar factory, the sources of liquid waste are normally from floor washing, mills, boiler blowdown, drum filter washings, excess condensate and from entertainment of juice/syrup/massecuite in evaporator/pans. The standards for discharge of environmental pollutants from the sugar industry have been stipulated under the Environment (Protection) Rules, 1986. These standards set the permissible limits for BOD and suspended solids (Table 13). In majority of cases, the effluent is used for irrigation of sugarcane fields around the sugar factory. The factories adopt any of the following methods for treatment of effluent:

- lagooning
- lagooning followed by aeration
- equilisation and neutralisation followed by aeration by surface aerators.

The sugar factories can reduce water pollution by adopting suitable measures like recirculation of cooling water, elimination of overflow/ leakages of juices and other sugar materials etc. Recently, the sugar industry has also started thinking of adopting anaerobic digestion for treatment of wastewater. However, the technology is still in the R&D stage. Infact, it is possible to limit the water pollution within acceptable limits through strict water management in the sugar factories.

Table 13. Environmental standards for sugar industry

Bio-chemical Oxygen Demand, 5 day, 20°C	Concentration not exceeding 100 mg/litre for disposal on land and 30 mg/litre for disposal on surface water.
Suspended solids	Concentration not exceeding 100 mg/litre for disposal on land and 30 mg/litre for disposal on surface water.

A study titled 'Implementation status of the pollution control measures in major polluting industries' undertaken by CPCB in March 1995 lists a total of 1551 large and medium units in the country which fall under 17 highly polluting industrial sectors. Of these, the maximum number i.e. 391 fall in the sugar sector. Of these 391 units covered, 256 units are having 'adequate facilities to comply with the standards'. **Of the remaining 118 non-complying units which 'do not have adequate facilities to comply with the standards'**, 103 are pre-1981 and 15 are post 1981 - pre 1991 period. These 118 units fall under the following categories:

- State public sector units 46
- Cooperative sector units 49
- Private sector units 23

CHAPTER 6

Conclusion

One of the industry sectors covered for detailed analysis under Phase - I of the Energy Efficiency Support Project is the sugar sector. Study of the sector revealed that the energy efficiency in the Indian Sugar Industry is low as compared to the mills in developed countries and considerable scope exists for increasing the end use energy efficiency in the sugar factories. The overall primary energy consumption in the sector is around 100 million Gcals which is considerably high than many of the other sectors studied under this project. The most promising implementable energy conservation measure identified is biomass based cogeneration. Success of cogeneration in the Indian Sugar Industry is highly dependent upon the policies of Government of India and various State Government's in terms of the financial, regulatory and contractual issues. The recent initiatives taken by the Ministry of Non Conventional Sources (MNES) in formulating a National Programme on Biogas based Cogeneration should go a long way in promoting cogeneration amongst sugar mills. In addition to the congeneration option, a number of other energy saving means are applicable for the sugar industry, details of which are provided in the report. Based on a comparative assessment, it is recommended to consider sugar sector for assistance under the Phase - II of the ESP programme.

Phase-II of the project primarily covers various initiatives like undertaking energy and environment audits, feasibility studies, training programmes and promotional campaigns for the industry sectors identified under the phase-I of the study. Some of the units which can be considered for carrying out energy and environmental audits are listed in Annexure VI. A number of organisations are working in the field of promoting energy conservation and technology upgradation in the Indian sugar industry. A list of such organisations along with the broad areas of their activity is given in Annexure VII.

STATEMENT SHOWING THE STATE WISE CANE ACREAGE, PRODUCTION AND YIELD

	Area (thousand hectares)				Production (thousand tonnes)				Yield (tonnes/HA)			
States	1990-91	1991-92	1992-93	1993-94	1990-91	1991-92	1992-93	1993-94	1990-91	1991-92	1992-93	1993-94
Andhra Pradesh	182.1	202.2	171.1	175.3	12667.3	15056.7	12163.2	13553.4	69.5	74.5	71.1	77.3
Assam	35.8	37.8	39.9	35.8	1522.0	1454.0	1547.7	1373.9	42.5	38.5	38.8	38.4
Bihar	148.7	144.9	132.9	119.9	7805.3	7076.6	6031.6	4397.9	52.5	48.8	45.4	36.7
Gujarat	118.3	120.2	127.2	128.4	10599.7	10239.4	10872.1	10232.1	89.6	85.2	85.5	79.7
Goa	1.8	1.9	1.9	1.6	84.0	88.0	80.4	71.4	46.7	46.3	42.3	44.6
Haryana	148.0	161.0	134.0	111.4	7800.0	9000.0	6550.0	6420.0	52.7	55.9	48.9	57.6
Karnataka	272.3	285.3	261.5	244.5	20964.0	24117.0	22479.6	20884.1	77.0	84.5	86.0	85.4
Kerala	8.0	8.1	6.2	5.6	542.9	547.1	428.3	447.9	67.8	67.5	69.1	80.0
Madhya Pradesh	39.4	46.2	39.0	48.7	1391.2	1646.3	1324.6	1725.0	35.3	35.6	34.0	35.4
Maharashtra	444.0	453.3	403.8	344.1	38416.2	36186.6	30853.5	27891.5	86.5	79.8	76.4	81.1
Nagaland	3.8	3.3	4.0	4.0	130.0	140.0	200.0	188.0	34.2	42.4	50.0	47.0
Orissa	49.0	42.5	16.0	13.4	3549.0	2744.6	754.2	781.0	72.4	64.6	47.1	58.3
Punjab	101.0	109.0	112.0	77.0	6000.0	6920.0	6369.0	4710.0	59.4	63.5	56.9	61.2
Rajasthan	22.8	31.2	24.3	20.6	1203.1	1360.7	1129.0	1020.0	52.8	43.6	46.5	49.5
Tamilnadu	232.9	238.0	215.6	261.7	23480.2	24886.8	23064.4	27574.6	100.8	104.6	107.0	105.4
Uttar Pradesh	1855.6	1932.6	1857.5	1773.9	103562.2	111098.2	102929.1	104839.4	55.8	57.5	55.4	59.1
West Bengal	12.2	17.0	15.4	10.3	859.3	969.3	888.7	595.4	70.4	57.0	57.7	57.8
Pondicherry	2.8	3.5	2.6	2.4	256.0	285.9	186.8	172.8	91.4	81.7	71.8	72.0
Others	7.5	6.4	6.9	7.2	212.7	177.9	181.4	180.5	28.4	27.8	25.3	25.1
All India	3686.0	3844.4	3571.8	3385.8	241045.5	253995.1	228033.4	227058.9	65.4	66.1	63.8	67.1

Source. ISMA, 1995

Annexure II

UTILISATION OF SUGARCANE FOR DIFFERENT PURPOSES

Years	Production of Sugarcane ('000 Tonnes)	Cane Used For ('000 Tonnes)			Percentage of Sugarcane production		
		Production of White Sugar	Seed, Feed & Chewing etc.	Gur & Khandsari	Production of White Sugar	Utilised For Seed, Feed & Chewing etc.	Gur & Khandsari
1976-77	153007	48967	18317	85723	32.0	12.0	56.0
1977-78	176965	67288	21029	88648	38.0	11.9	50.1
1978-79	151655	59715	17957	73983	39.4	11.8	48.8
1979-80	128833	39048	15104	74681	30.3	11.7	58.0
1980-81	154248	51598	18201	84449	33.4	11.8	54.8
1981-82	186358	87356	19278	79724	46.9	11.8	41.3
1982-83	189506	82694	22371	84441	43.6	11.8	44.6
1983-84	170476	59022	21136	93918	33.9	12.1	54.0
1984-85	170319	60092	21000	82779	35.3	12.3	52.4
1985-86	171681	68576	20326	82779	40.0	11.8	48.2
1986-87	186090	85184	22242	78664	45.8	12.0	42.3
1987-88	196737	93943	23608	79186	47.8	12.0	40.2
1988-89	203037	85693	24161	93183	42.2	11.9	45.9
1989-90	225569	111149	26843	87577	49.3	11.9	38.8
1990-91	241046	122287	28552	90207	50.7	11.9	37.4
1991-92	253995	133987	26669	93339	52.8	10.5	36.7
1992-93	228033	103002	27136	97895	45.2	11.9	42.9
1993-94	227059	98348	27247	101464	43.3	12.0	44.7

Source. ISMA, 1995

STATEWISE SUGAR PRODUCTION IN INDIA

('000 tonnes)

State	84-85	85-86	86-87	87-88	88-89	89-90	90-91	91-92	92-93	93-94
A.P	355	406	530	544	507	566	701	843	540	647
Bihar	144	350	299	312	319	334	415	462	328	230
Gujarat	403	558	576	578	578	667	831	753	751	826
Haryana	137	161	289	272	280	336	375	489	345	308
Karnataka	441	508	611	745	702	796	942	1032	847	831
Kerala & Goa	15	13	18	16	22	23	18	26	19	10
M.P	51	62	71	85	63	72	103	128	60	37
Maharashtra	2311	2388	2388	2795	2629	3923	4119	4213	3360	2746
Punjab	142	146	234	210	245	295	275	384	409	311
Rajasthan	19	13	23	6	14	12	23	37	24	16
Tamil Nadu & Pondicherry	628	862	873	835	1058	925	1231	1327	1021	1122
U.P. Central	654	746	1129	1173	972	1264	1176	1497	1192	1055
U.P. East	267	456	617	656	620	702	769	953	787	677
U.P. West	557	448	811	836	710	1042	1030	1204	878	983
Others-Assam, Orrisa, Nagaland & W. Bengal	20	19	34	42	33	31	39	56	48	34
All India	6144	7016	8501	9110	8752	10988	12047	13404	10609	9833

Source. ISMA, 1995

Annexure IV

STATEMENT SHOWING FACTORIES IN OPERATION, OPENING STOCK, PRODUCTION, CONSUMPTION AND EXPORTS

(Lakh tonnes)

Season	No. of factories	Opening Stock	Production	Import	Availability	Off take for Internal Consumption	Exports
1960-61	174	6.05	30.28	-	36.33	21.27	3.03
1961-62	180	12.03	27.30	-	39.33	25.88	3.33
1962-63	186	10.12	21.35	-	31.47	24.86	5.16
1963-64	194	1.55	25.62	-	27.17	23.07	2.43
1964-65	198	1.67	32.32	-	33.99	24.69	2.58
1965-66	200	6.72	35.72	-	42.04	28.10	4.30
1966-67	200	9.64	21.59	-	31.23	26.01	2.18
1967-68	200	5.24	22.43	-	27.67	22.10	1.23
1968-69	205	4.34	35.58	-	39.92	26.09	0.79
1969-70	215	13.04	42.61	-	55.65	32.69	2.12
1970-71	215	20.84	37.40	-	58.24	40.27	3.90
1971-72	220	14.07	31.08	-	45.15	37.90	1.33
1972-73	228	5.92	31.72	-	44.64	35.13	1.10
1973-74	229	8.41	39.48	-	47.89	35.22	4.39
1974-75	246	8.28	47.95	-	56.23	35.14	9.41
1975-76	252	12.07	42.62	-	54.69	36.87	9.50
1976-77	270	8.32	48.40	-	56.72	37.56	3.41
1977-78	287	15.75	64.57	-	80.32	44.90	2.53
1978-79	298	32.89	58.42	-	91.31	62.09	9.36
1979-80	299	20.86	38.58	1.63	61.07	52.32	2.30
1980-81	314	6.45	51.47	1.53	59.45	49.70	0.60
1981-82	319	9.15	84.36	0.77	94.28	57.43	4.15
1982-83	320	32.70	82.30	-	115.00	64.81	4.25
1983-84	325	45.87	59.17	0.94	105.98	75.55	6.59
1984-85	338	23.74	61.43	11.87	97.04	80.93	0.32
1985-86	341	15.79	70.16	16.19	102.14	82.72	0.36
1986-87	353	19.06	85.01	9.53	113.60	86.87	0.22
1987-88	356	26.53	91.10	0.71	118.34	93.85	0.18
1988-89	366	24.31	87.52	-	111.83	99.36	0.18
1989-90	377	12.29	109.88	2.42	124.59	102.15	0.23
1990-91	385	22.21	120.46	-	142.67	107.14	2.23
1991-92	392	33.30	134.04	-	167.34	112.70	5.62
1992-93	393	49.02	106.09	-	155.11	118.75	4.11
1993-94	394	32.25	98.33	2.00	150.58	119.60**	0.10

** Provisional

Source. ISMA, 1995

INCREMENTAL CAPITAL COST FOR A TYPICAL COGENERATION SCHEME IN POWER MAXIMISATION MODE FOR A STANDARD NEW 2,500 TCD SUGAR PLANT

		Rs. Lakhs
1.	Incremental capital cost of 2 x 37 T/hr, 65 ata, 480°C spreader stoker dumping grate bagasse fired boilers with automation as compared to 2 x 32 T/hr, 33 ata 380°C boilers	200
2.	Incremental capital cost of 1 x 15 MW, double extraction condensing turbo-alternator set of 6600/11000 volts as compared to 1 x 2.5 MW back pressure 440 V turbojet.	1,600
3.	Incremental cost of steam piping, transformers, grid paralleling system, electrical distribution boards, bagasse handling equipment, extra civil works, water treatment plant etc.	200
4.	Contingencies, interest during construction period etc.	300
	Total capital cost (Incremental)	2,300

Note: The above incremental capital cost will result in 9.0 MW of surplus power export for 150-180 days a year during the period November to April with bagasse savings.

Source: GOI, 1993

Annexure VI

UNITS WHICH CAN BE CONTACTED FOR CARRYING OUT ENERGY AND ENVIRONMENTAL AUDITS

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1. South India Sugars Ltd
Mundiampakkam
Vilupurram Taluk - 605 601
South Arcot Distt. (T.N)

Tel: 22447
Fax: 04146-23116

Regd Office:
39, Armenian Street
Madras - 600 001

Contact Person		Mr V Thirunavukarasu G.M. (Works)
Plant Capacity		3500 TCD
Year of commissioning		1965
Ownership		Private
Cane Crushed - 1994/95 (tonnes)		633585.42
Average crushing rate (tcd)		3470
Bagasse consumed (tonnes)		203345
Design boiler pressure (kg/cm^2)	16.2 (4 nos)	17.6 (1 no)
Design temperature (°C)	260	340
Specific electricity consumption (Kwh/t of cane)		
Self generated		14.29
Purchased		1.57
Total		15.87
Specific steam consumption (% on cane)		55.00

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2. Riga Sugar Company Ltd.
Railway Station Riga (N.E. Rly)
P.O. Riga, Distt. Sitamarhi
(Bihar)

Tel: 32205/32385/3853

Regd Office: 14, Netaji Subhas Road Calcutta - 700 001		Tel: 2205194/2200681 Fax: 2203663
Plant Capacity		2500 TCD (to be expanded to 3000 TCD in 1996-97)
Year of commissioning		1932
Ownership		Private
Cane crushed - 1994/95 (tonnes)		329464.26
Average crushing rate (tcd)		1734
Bagasse consumed (tonnes)		116741.73
Design boiler pressure (kg/cm^2)	11.6 (2 nos)	32 (1 no)
Design temperature (°C)	250	370
Specific electricity consumption (Kwh/t of cane)		
Self generated		18.78
Purchased		0.00
Total		18.78
Specific steam consumption (% on cane)		52.03

3. Upper Doab Sugar Mills
Shamli - 247 776
Distt. Muzaffarnagar (U.P)

Tel: 01318-50064/50082
Fax: 01318-50032

Regd Office: 4-A, Hansalaya 15, Barakhamba Road New Delhi 110 001	Tel: 3316409/3321827 Fax: 3722193
Plant Capacity (TCD)	3810
Year of commissioning	1933
Ownership	Private
Cane crushed - 1994/95 (tonnes)	747367.9
Average crushing rate (tcd)	3771.9

Bagasse consumed (tonnes)		116741.7	
Design boiler pressure (kg/cm^2)	14 (4 nos)	21 (1 no)	
Design temperature (°C)	275	290	
Specific electricity consumption (Kwh/t of cane)			
Self generated			
Purchased		21.45	
Total		1.14	
		22.59	
Specific steam consumption (% on cane)		53.44	

4. The Simbhaoli Sugar Mills Ltd. Tel: 0122-312664
Simbhaoli - 245 207
Distt. Ghaziabad (U.P)

Delhi Office: Tel: 3321413
802-803, Surya Kiran Building Fax: 3315424
19, Kasturba Gandhi Marg
New Delhi 110 001

Contact Persons	Mr Satwant Singh Executive Director Mr Sanjay Tapriya Company Secretary		
Plant Capacity (TCD)		6250 TCD (1994-95)	
Year of commissioning		1933	
Ownership		Private	
Cane crushed - 1993/94 (tonnes)		758451	
Average crushing rate (tcd)		4440.3	
Bagasse consumed (tonnes)		243701	
Boiler efficiency (%)	72	59-65	72-73
Design pressure (kg/cm^2)	22 (1 no)	12 (3 no)	33 (2 no.)
Design temperature (°C)	330	290	370

Specific electricity consumption (Kwh/t of cane)	
Self generated	14.85
Purchased	NA
Total	NA
Specific steam consumption (% on cane)	50 to 54

5. Sakhti Sugars Ltd. Tel: 04256-8241

Sivaganga Unit

Padamathur P.O.

Pasumpon Distt - 623 566

Head Office: Tel: 0422-211551/06762-2739

190, Race Course Road Fax: 0422-217329

Coimbatore - 641 018

Contact Person	Mr S Kittuswamy DGM (Operations)
Plant Capacity (TCD)	2500 (Sivaganga unit)
Year of commissioning	1989
Ownership	Private
Cane crushed - 1992/93 (tonnes)	189247
Bagasse consumed (tonnes)	51242
Specific electricity consumption (Kwh/t of cane)	
Self generated	NA
Purchased	NA
Total	28.22
Specific steam consumption (% on cane)	60.50

6. Aruna Sugar & Enterprises Ltd. Tel: 04143-82242

Sugar Division Fax: 04143-82253

Arunapuram, Eraiyur

Pennadam R.S. - 606 111

S.A.V Distt. (T.N.)

Regd. Office:		Tel: 8271841
Aruna Centre		
145, Sterling Road		
Madras - 600 034		
Contact Persons	Mr K Jayachandran	
	Vice President	
	Mr R Ramgopal	
	DGM (Tech.)	
Plant Capacity (TCD)		5000
Year of commissioning		1965

Ownership	Private
Cane crushed - 1992/93 (tonnes)	671975
Bagasse consumed (tonnes)	206622
Specific electricity consumption (Kwh/t of cane)	
Self generated	
Purchased	NA
Total	NA
	22.20
Specific steam consumption (% on cane)	56.00

7. Daurala Sugar Works		Tel: 0121-72608/77028
(A unit of DCM Shriram Industries Ltd.)		Fax: 0121-543927
Daurala, Distt. Meerut (U.P)		
Head Office:		Tel: 3321413
10th Floor, Kanchenjunga		Fax: 3315424
18, Barakhamba Road		
New Delhi - 110 001		
Contact Persons	Mr Nitish Brahma	
	Sr Executive Director	
	Mr V K Rohatgi	
	G.M (Sugar)	
Plant Capacity (TCD)		5000

Year of commissioning		1932	
Ownership		Private	
Cane crushed - average (tonnes)		1000000	
Average crushing rate (tcd)		5000	
Bagasse consumed (tonnes)-average		300000	
Boiler efficiency (%)	64	65	
Design pressure (kg/cm^2)	20 (3 no)	33 (1 no)	43 (2 no.)
Design temperature (°C)	300	380	360
Specific electricity consumption (Kwh/t of cane)			
Self generated			
Purchased		26.0	
Total		1.4	
		27.5	
Specific steam consumption (% on cane)		51 to 56	

8. Andhra Sugars Ltd. Tel: 08819-2911/2556

Tanuku - 534 215 (A.P.)

Regd Office: Tel: 08819-4911

Venkatarayapuram Fax: 08819-4168

Tanuku - 534 215

Contact Person	Mr B B Ramaiah Managing Director (Tech)	
Plant Capacity		5000
Year of commissioning		1952
Ownership		Private
Cane crushed - 1992/93 (tonnes)		424282
Bagasse consumed (tonnes)		134625

Specific electricity consumption (Kwh/t of cane)	
Self generated	
Purchased	NA
Total	NA
	23.83
Specific steam consumption (% on cane)	60.02

9. Sri Chamundeswari Sugars Ltd.
K M Doddi - 571 422
Mandya Distt.(Karnataka)

Regd Office:		Tel: 577033/ 577034/ 55880:
No 76, Ulsoor Road		Fax: 5586119
Bangalore - 560 042		
Contact Person	Mr M Srinivasan	
	Executive Director	
Plant Capacity (TCD)		4000
Year of commissioning		1974
Ownership		Private
Cane crushed - 1992/93 (tonnes)		796776
Bagasse consumed (tonnes)		255016

Specific electricity consumption (Kwh/t of cane)	
Self generated	
	NA
Purchased	NA
Total	17.76
Specific steam consumption (% on cane)	49.50

10. Ponni Sugars & Chemicals Ltd. Tel: 04289-40351
Ponni, Erode - 638 007 Fax: 04289-40015
Tamil Nadu

Regd Office:
ESVIN House
Perungudi, Madras - 96

Plant Capacity (TCD)	2500
Year of commissioning	1984
Ownership	Private
Cane crushed - 1994/95(tonnes)	429194
Average crushing rate (tcd)	1465
Bagasse consumed (tonnes)	Nil (Entire Bagasse production is sold)
Other fuels consumed (tonnes)	
Coal	30278
Lignite	11465
Coconut shells	2524

Note : Plants listed at S. No. 1,2,3 & 10 are aware of the Energy Efficiency Support Project and had responded to the questionnaire which TERI has sent under the Phase I of the project.

SUGAR ORGANIZATIONS

1. National Sugar Institute, Kalyanpur, Kanpur

Established in 1936, this is the premier institute in the country engaged in training and research in sugar technology. It also undertakes technical education in all branches of sugar engineering. It is under the administrative control of the Ministry of Food & Civil supplies. It provides advisory services to the sugar factories in order to improve their day to day problems. Assistance is also provided to the Central and State Governments in matters relating to sugar and allied industries.

2. Sugar Technology Mission, Government of India

Government of India has recently setup a Sugar Technology Mission to look into the various issues concerning technology upgradation in the Indian sugar Industry. Set up jointly by the Ministry of Food and Ministry of Science and Technology in 1994, the broad objectives of the mission are higher productivity, improved sugar quality, reduction in energy consumption, reduction in pollution, value addition to by-products and overall reductions in cost of production through technological innovations. The mission also addresses the issue of improving the financial health of sugar mills through adoption of cogeneration.

3. Sugar Technologists Association of India, 21, Community Centre, East of Kailash, New Delhi

The Association, started in 1925, aims at promoting the knowledge of sugar technology amongst the persons working in this field. It holds a Annual Convention every year which provides a forum for exchange of technical & scientific information.

4. Indian Sugar Mills Association, Sugar House, 39, Nehru Place, New Delhi - 110 019

It is an All India Organisation of sugar mills which aims at protecting and promoting the interests of its members. It maintains intimate contact with all regions in India through a network of branches and affiliated regional associations. It brings out various publications/journals devoted to technical, statistical and policy issues concerning sugar industry.

5. National Federation of Cooperative Sugar Factories Limited, Vaikunt, 82-83, Nehru Place, New Delhi

National Federation of Cooperative Sugar Factories Limited is an All India Organisation of the Cooperative sugar factories in India. It represents the views of the cooperative sector on all matters relating to the sugar policy, fixation of sugar & sugarcane prices etc. It also provides technical advice and suggests measures for increasing the operational efficiency of cooperative sugar mills in the country. NFCSF also brings out publications/journals devoted to technical, commercial and other issues concerning sugar industry.

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